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Virtual Reconstructions of Historical and Cultural Heritage Sites and Their Conventional Grading

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***Abstract**:*

Numerous historical and cultural reconstructions without an established systematization have accumulated in the contemporary virtual space. At the same time, they differ significantly from one another. In this regard, a rather critical task at this point is the gradation and systematization of information on historical and cultural reconstructions. To meet the objective of this study, basic concepts were investigated, such as 'virtuality', 'visuality' and others, which are necessary for the determination of the final results.

The article considers conditional grading of virtual reconstructions developed by the authors. Various examples and options are provided for every type of reconstruction, making it possible to subdivide the currently available historical and cultural reconstructions into three primary groups:

First group - closed virtual reconstruction: local, narrative or retrospective.
Second group - research or location virtual reconstruction: perimetral or cognitive.
Third group - projected virtual reconstruction: static or effective (complex sensor).

Classification into three primary groups and associated six types greatly facilitates the orientation in the various historical and cultural virtual spaces, including their producers and consumers, also allowing to update the terminological communication of researchers and developers in this subject field.

***Keywords:** Computer technologies, Historical reconstruction, Archaeology, Virtual reconstruction, Reconstruction of historical and cultural heritage sites*.

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1. Introduction

The rapid development of the virtual trend in science, technology and art is accounted for by the improvement of computer technology. The technological virtual world is a form of relationship between individuals dictating new ways of understanding the world and movement in time and space, as well as determining the means of expressing knowledge. The virtual environment and immersion therein will soon be commonly available similarly to the Internet and cellular communication.

Currently, the market is filled with a large number of virtual projects based on a variety of historical documentation. It should be noted that their technical and visual features greatly vary. For instance, one can create a virtual reconstruction a household item, as well as an entire city. The first reconstruction allows to simply observe an individual object, whereas the second one allows the user to 'move' in the reconstruction, supporting the illusion of being inside the environment. Numerous virtual developments are presently referred to by a single term 'virtual reconstruction'.

The concept of 'virtuality' has been differently interpreted and applied by philosophers and thinkers of different time periods long before the invention of the computer. In the time of Cicero, the concept of 'virtus' ('virtue', 'valour') derived from the word 'vir' ('man') denoted courage or bravery, and often expressed a certain firmness of spirit leading to resolute and courageous actions (Bragova, 2011). In other words, the basis of the term 'virtuals' has been derived from the word 'virtus', which denotes ability, power, strength, courage, potential and capacity, qualities which can manifest themselves under certain conditions. The origin of its modern meaning is the English language, in which the expression 'virtual reality' formed during the computerization period. In the 1990s it was adopted by practically all other languages of the world.

In the primary general scientific understanding, the adjective 'virtual' used to have another synonym - potential. Representing a word from the computer lexicon, it is a synonym of the following terms:

- network (virtual space - network space);
- electronic (virtual shop - electronic shop);
- Internet (virtual world - Internet world) (Marinova, 2013).

With the development of informatics at the end of the 20th century, the word 'virtual' acquired another meaning – 'not having a physical embodiment or differing from an actually existing object (Krysin, 2006). Thus, one can define 'virtual' as something which has all the attributes of an object or action, but only exists in the computer environment.

The development of the technical capabilities of computers resulted in the spread of the 'virtual reality' concept. In the early 1960s Ivan E. Sutherland (Utah State University, USA) redefined computer graphics and created a panoramic display allowing to navigate in the graphical space by simple turning of the head. He

presented the results of his efforts in work (Sutherland, 1965). In the same years, a 'virtual aircraft cockpit' was developed for the US Air Force. This idea was further developed as the display was supplemented with a headgear and gloves with sensors. A new word formation 'augmented reality' originally proposed by Tom Caudell (Boeing, USA) appeared with the invention of the headgear. It denotes a direct or indirect real-time display of reality with its elements complemented by a virtual space created on the computer (sounds, video, graphics and GPS data). In the early 1970s Frederick Phillips Brooks (North Carolina State University, USA) created a system which allowed to manipulate graphic objects using a mechanical manipulator (Druk & Rudnev, 1995).

As the technologies became more advanced and complicated, they were introduced into various areas of personal life (education, entertainment, science and museum studies). The development of 'virtual reality' occurred in accordance with the following stages (Beau *et al.*, 2008):

- Imagination period: 1980-1990s (between the releases of Tron (1982) and Matrix (1999) motion pictures), when the mythology of virtual worlds was established, according to which the alternative reality can rejuvenate the world and break the boundaries between the real and the imaginary.
- Technology period: the starting point for technical devices developed by Jaron Lanier in the late 1970s represented by body motion detectors, gloves and a latex shirt which transferred motion data. He introduced the concept of 'virtual reality' designating three-dimensional real-world models created with the use of 3D-software; the establishment of their complete images and the presence of a person therein.
- Sociality period (2000s): an Internet world visited by millions of people daily. Virtual worlds are absolutely real, and some of them, for instance, manage the world economy.

The following properties of a virtual event were determined In the laboratory of virtualistics established in 1991 on the basis of the Human Institute Center under the Russian Academy of Sciences headed by Nosov (1997): unaccustomability, abruptness, fragmentarity, objectivity, variability of the physicality status, variability of the consciousness status, variability of the personality status, variability of the willpower status. It was noted that the intensity of the manifestation of these properties varies depending on each particular case. Virtuality is considered as a certain reality with specific properties:

- Descendancy - dependence and secondary nature of virtuality with respect to the active environment. It can have a relative form, i.e. virtual reality can generate a virtual reality of the next level, becoming a constant reality with respect to the latter, and so on ad infinitum.
- Relevance - virtual reality relevantly exists only here and now, i.e. when the generating environment is active.
- Autonomy determined by the presence of individual space, time and laws of existence in the virtual reality.

- Interactivity; having an opportunity to participate in the process, and being able to influence the process (Nosov, 1997).

The determinative property of virtuality is its interactivity, enabling the user to be an active participant of activities and directly influence cycles and processes.

Today, technologies have made it possible to reproduce the virtual world with sufficient perceptibility and "immerse" in it, receiving stronger feedback and sensations. The user can find himself part of the virtual space where all of his senses are being stimulated. One can simulate practically any conditions, situations and life cycles of various real and fictional worlds.

According to article (Technology - virtual, the result is real,1997), depending on the nature of human interaction with the virtual environment, the following three types of environment can be distinguished: passive, research and active. In a passive environment, the user is a mere spectator: he receives information on the virtual reality, but cannot control it. Apart from observation, a research virtual environment allows the user to move around it. An active environment allows the user to interact and change the environment at his/her discretion, for instance, controlling the instruments of a virtual aircraft from its cabin.

Thus, the classification of virtuality types currently does not have a unified basis, which significantly complicates the orientation in the great variety of historical and cultural virtual space for their producers and consumers.

2. Materials and Methods

Taking as a basis the aforesaid classifications of virtual environment perception, one can systematize the numerous computer reconstructions of historical and cultural heritage over the last decade as follows:

1. A closed virtual reconstruction in which the following two subgroups can be distinguished:
   - local 3D reconstruction;
   - narrative or retrospective 3D reconstruction.
2. Research or local virtual reconstruction:
   - perimetral 3D reconstruction;
   - cognitive 3D reconstruction.
3. Projected virtual reconstruction:
   - static 3D reconstruction;
   - effective (complex sensor) 3D reconstruction.

3. Results and Discussion

1. Passive or closed virtual reconstruction is a time-limited scene of a short film (video). The viewer cannot influence the virtual world inside the displayed video, only being able to observe the actions of virtual residents, virtual nature, phenomena, and processes. The nature of such videos is subdivided into two categories:

1.1. Local reconstruction demonstrating the reconstructed world without any narrative history giving an overview of a given space. The following projects are typical examples of this type of reconstruction:

- Lussonium in the museum of Paks (Hungary). Two video films are displayed as part of the museum project: reconstruction of the military camp dating back to the Roman Empire period and a virtual 3D reconstruction of a small fragment of a Roman statue. It allows visitors of the exhibition not only to observe the statue in its complete form, but also demonstrates its location within the camp (Lussonium).
- Colonia Iulia Emona, Ljubljana, Slovenia. A virtual 3D reconstruction used not only as a museum exhibit, but also as an informative and educational film shown on national television and in schools (Colonia Iulia Emona).
- The Bridge Building Squad No.19 museum is a presentation comprising a virtual space of architectural transport nodes erected by this enterprise in various time periods (Museum of History of bridge-building unit №19).
- A virtual reconstruction of an Imenkovo culture settlement dating back to 7th century based on archaeological excavations in the vicinity of the town of Tetyushi (the Middle Volga region) demonstrating an ancient settlement with its anticipated lifestyle (Nigmatullina *et al.*, 2015).

1.2. Narrative or retrospective reconstruction – a visualization of history in the form of a film or a sequence of erection and modifications of a site or a portion of space. Examples include the following projects:

- Karnak (Welcome to digital Karnak) developed by the Experiential Technologies Center of the University of California (Welcome to digital Karnak). The project includes over 60 three-dimensional designs: obelisks, temples, courtrooms, pylons, enclosing walls, and others. Each site is displayed in the form of reconstructions of all periods of its existence with the visualization of the successive stages of their construction on the basis of archival layouts and drawings. The project was supplemented with the latest research results obtained using modern technologies. Web pages include a detailed description and bibliography for each particular building. One of the primary features of the project is the opportunity to observe the architectural variations of the buildings over time with the use of a variable model reflecting the lifecycle of the temple from the first assumptions of its form to its present condition. This allows to visualize how the site has changed over the 1500 years of its existence (Razuvalova & Rudenko, 2015).
- Die Baugeschichte des Florentiner Doms (Technische Universität Darmstadt, Germany), (Art and Exhibition Hall of the Federal Republic of Gemany, 2013) representing the technology of the stepwise construction of the cathedral and the technical features of its erection.
- A 3D reconstruction project demonstrated in the Secrets of the Parthenon motion picture also describes the development history of an architectural site (Secrets of the Parthenon, 2008).

- Le navi di Caligola is a reconstruction of an ancient Roman ship belonging to Caligula and the technology of its hoisting from the depths of a lake in which it was discovered (Museo navi romane).

2. Research or location reconstruction. Location (from Latin 'locatio' — arrangement, position) - determination of an object's location, also denoting an arrangement and location used in computer games in relation to a certain part of the virtual world of a game. Players use the word 'location' to describe a level of a game, labyrinth, or space. Thus, research reconstruction is a computer model of historical and cultural heritage, simulating the real space with the use of locations. The user can move inside the model using various devices: mouse, keyboard, joystick or other auxiliary equipment. A location is capable of certain interaction with the user, creating a presence effect with the possibility of orientation and movement around it, as well as vertical and horizontal movement of the player's view.
This group can be subdivided into two categories:

2.1. Perimetral direction – 'action' games in which the reconstruction borders on the parameters of the computer game, where movement in space is controlled by means of auxiliary devices:

- Historical and cultural heritage of the city of Yeniseisk (Historical and cultural heritage of the Yeniseisk town). The project gives an opportunity not only to view videos featuring the reconstruction of religious buildings (the Epiphany Cathedral, the Resurrection Church, Church-Belfry of Saints Zachary and Elizabeth, etc.), but also download the locations for their further application.
- The Grand Duchy of Lithuania is a series of 3D reconstructions, one of which represents a location featuring an ancient castle and its courtyard located in the territory of Belarus (Grodno Region, Smarhon District, Krevo village), (Grand Duchy of Lithuania).
- A virtual reconstruction of the Passion Monastery in Moscow (mid-17th - early 20th centuries): an analysis of the evolution of spatial infrastructure on the basis of 3D modelling techniques. The user is given access to a virtual reconstruction realized in a 3D mode. The user can also watch a video with an overview of a reconstruction model of Strastnaya Square. Two different viewing options are provided: online with the Unity Web Player, and offline (Multimedia Information System: Virtual reconstruction of the Moscow Passion Monastery (XVII mid - early XX centuries): analysis of the evolution of spatial infrastructure based on the methods of 3D modeling).
- Grotte de Lascaux (France) is a renowned ancient cave located in virtual space which the user can 'walk' through, viewing the wall paintings created by primeval people (Grotte de Lascaux).
- a virtual reconstruction of 14th century Great Bolgar in the form of a cognitive game with a realistic architecture household environment and its population typical of the period in question, an urban layout reconstructed on the basis of the available archaeological data, which offers informative references concerning various elements of reconstruction characterized in

(Khafizov *et al.*, 2015) by various reliability degrees (reliable, moderately reliable, poorly reliable, conditionally reliable, or fictional)

2.2. Cognitive category consisting in the application of the location concept. At the same time, the user is capable of not only viewing, but also altering certain elements of the reconstruction:

- The aforesaid Grand Duchy of Lithuania project features a reconstruction of Halshany Castle providing a possibility of a stepwise restoration of its original appearance (Grand Duchy of Lithuania).
- The Virtual Paul's Cross Project (North Carolina State University at Raleigh), (Virtual Paul's Cross Project). A distinctive feature of this visual reconstruction is the background audio and sound effects with various degrees of 'saturation': the roar of a crowd of five hundred to two and a half thousand people listening to the voice of the preacher John Donne. The user can select the location and number of people on the square in the course of listening.
- Cognitive reconstruction also includes the reconstruction of the handwriting of certain personalities (Koval). These reconstructions feature the recreation of the individual characteristics of the handwriting of famous people. After the completion of a font file, the user is able to print with the use of his favourite poet's handwriting on his computer.

3. Projected virtual reconstruction allowing to arrange the ambient space in a way that it only exists here and now, with a sense of involvement in the unfolding process. This category of virtual reconstructions can be subdivided into the following two components.

3.1. Static reconstruction – a fixed inactive space surrounding the viewer:

- The Palazzo Valentini museum (Rome, Italy) features permanently exhibited archaeological remains of ancient Roman houses discovered under the palazzo (Le Domus Romane Palazzo Valentini). The characteristic feature of the exposition is that the reconstruction of the 3D interior of the house with the original wall and column paintings and the floor mosaic is projected directly onto the surviving surfaces (whereas the actual space is conserved in the form in which it was discovered). The reconstruction projection allows the user to imagine what the interior was like in ancient times.

3.2. Effective or complex sensor reconstructions comprise holograms exhibited in museum expositions:

- The ABBA museum in Stockholm gives an opportunity to 'put on' the costumes of the performers and dance on stage as part of the famous band represented in the form of a hologram (ABBA The Museum).

- A holographic theatre in the Yanka Kupala museum in Minsk features a poet's hologram which can be viewed by the user on visiting the personal account (Literary Museum Yanki Kupaly).
- The Le Roc aux Sorciers centre of excursion and educational activities features a twenty-five-meter 3D replica of the friso of the ancient cave. The Le Roc aux Sorciers cave in France was discovered in 1950, and access of general public to the site is prohibited for preservation purposes. A full-size electronic copy with paintings and engravings reconstructs the original stone texture and colour, demonstrating various lighting effects in different hours of the day on sculptures and scenery elements (Le Roc aux Sorciers).
- The Virtual Archaeological Museum in Ercalano (MAV, Naples province, Italy) comprises a movie theatre equipped with a vibrating platform simulating an earthquake, and a virtual reconstruction of the eruption of Vesuvius (MAV - Museo Archeologico Virtuale).

4. Conclusions

The developed classification of virtual reconstructions demonstrates the versatility and diversity of the final visual product in terms of its technical properties and perception degree. Visual and virtual reconstructions represent an integral part of modern archaeology, architecture, history and museum studies. Numerous scientific institutions worldwide are engaged in scanning and restoration of ancient cultural sites. Modern technical capabilities make it possible to accurately recreate in detail the monumental cultural monuments, individual items of arts and crafts, and even people.

The clarity and activity of virtual reconstructions has a positive impact on the cognitive aspect of the museum process, as it allows to convey historical and archaeological research information with the use of interactive entertainment without the distortion of its meaning. There are various approaches to the establishment and demonstration of virtual reconstructions.

The classification of virtual environments into three primary groups with six individual types proposed in this article greatly facilitates the orientation in diverse virtual spaces and the terminological communication of researchers and developers thereof.

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